

Stratigraphic Framework and Distribution of Lignite  
on Crowleys Ridge, Arkansas

By

Charles R. Meissner, Jr.

1983

Open-file Report 83-609

This report is preliminary and has not been reviewed for  
conformity with U.S. Geological Survey editorial standards  
and stratigraphic nomenclature.

## Table of Contents

	Page
Abstract .....	1
Introduction .....	4
Purpose of report .....	4
Location and size of area .....	4
Acknowledgements .....	5
Geologic Setting .....	6
Stratigraphy .....	7
Lithology and depositional environment of the Wilcox and Claiborne Groups .....	10
Wilcox Group .....	10
Claiborne Group .....	11
Near surface lignite exploration drilling .....	12
Cross section A-A' and area 1 (pls. 1 and 3) .....	13
Cross section B-B' and area 2 (pls. 1 and 4) .....	14
Cross section C-C' (pls. 1 and 5) .....	15
Cross section D-D' and area 3 (pls. 1 and 6) .....	16
Cross section E-E' (pls. 1 and 7) .....	17
Cross section F-F' and area 4 (north) (pls. 1 and 8) .....	18
Cross section G-G' and area 4 (north [cont.], middle, and south) (pls. 1 and 9) .....	19
Summary of significant lignite deposits on Crowleys Ridge .....	19
Chemical composition of Crowleys Ridge lignite .....	23
Utilization of Crowleys Ridge lignite and recommendation for further work .....	23
References .....	28

## Illustrations

Page

- Plate 1. Map of Crowleys Ridge, Arkansas showing near surface lignite exploration drill hole sites, lines of cross sections A-A' to G-G', and areas containing lignite 2.5 feet thick or more .....
- Plate 2. Regional geologic cross section along or adjacent to Crowleys Ridge, Arkansas .....
- Plate 3. Crowleys Ridge cross section A-A', near surface lignite exploration drilling, Clay County, Arkansas .....
- Plate 4. Crowleys Ridge cross section B-B' near surface lignite exploration drilling, Green County, Arkansas .....
- Plate 5. Crowleys Ridge cross section C-C', near surface lignite exploration drilling, Green County, Arkansas .....
- Plate 6. Crowleys Ridge cross section D-D', near surface lignite exploration drilling, Craighead County, Arkansas .....
- Plate 7. Crowleys Ridge cross section E-E', near surface lignite exploration drilling, Craighead County, Arkansas .....
- Plate 8. Crowleys Ridge cross section F-F' near surface lignite exploration drilling, Poinsett County, Arkansas .....
- Plate 9. Crowleys Ridge cross section G-G', near surface lignite exploration drilling, Poinsett and Cross Counties, Arkansas .....

## Figures

	Page
Figure 1: Composite stratigraphic column showing approximate relationship of coal zones and beds, Crowleys Ridge Arkansas .....	20
Figure 2: Index Map - Location of drill core samples .....	24

## Tables

Table 1: Areas containing significant lignite on Crowleys Ridge, Arkansas .....	22
Table 2: Summary of part of the proximate and ultimate analysis of 8 lignite samples (range and average as received) .....	25
Table 3: Averages of major and minor oxide composition of 8 lignite samples (laboratory ash) .....	25
Table 4: Potentially toxic elements and number of samples averaged (whole coal-parts per million) .....	26

## Abstract

The purpose of this report is to establish a stratigraphic framework of lignite beds and associated strata of Crowleys Ridge, Arkansas. Drill hole data provided by the Arkansas Geological Commission is used in the synthesis and interpretation. Areas containing lignite of potential resource value are also delineated.

To illustrate the regional stratigraphic framework of Crowleys Ridge, a cross section was constructed from logs of selected oil and gas test wells, along or adjacent to the north-south trending ridge over a distance of about 115 miles. This section reveals that lignite-bearing Tertiary formations dip gently southward along the ridge. The Paleocene-Eocene Wilcox Group forms the bedrock in the northern part of the ridge and successively younger bedrock of the Eocene Claiborne and Jackson Groups is identified in the central and southern part of the ridge. Crowleys Ridge is mantled with alluvium and loess of Quaternary age, and sand and gravel beds of the Lafayette Formation of Pliocene (?) age that unconformably overlie the Paleocene and Eocene rocks. The thickness of lignite-bearing sedimentary deposits ranges from 830 feet in the north to 2,480 feet in the south. The Wilcox, Claiborne, and Jackson Groups of Paleocene and Eocene age are believed to be fluvial-deltaic in origin.

The detailed vertical and horizontal stratigraphic characteristics and distribution of lignite beds in the sediments were determined by constructing seven cross sections from lithologic and geophysical logs of the lignite investigations on Crowleys Ridge by the Arkansas Geological Commission and private companies. Correlation and interpretation of the lignite-bearing strata reveal ten lignite beds of resource potential. These lignite beds range from a few inches to 9.5 ft in thickness and are assigned to

stratigraphic intervals that are designated as zone 1 through 7. Zone 1 is near the middle of the Wilcox Group and zone 7 is near the middle of the overlying Claiborne Group. Some of these lignite beds are correlated over distances as much as 30 miles. Other lignite beds thin to a few inches thick and disappear within short distances. Four areas are delineated on Crowleys Ridge that contain one or more lignite beds each 2.5 feet or more thick. Strippable lignite is limited to 300 feet in this area, therefore, all holes were drilled to 300 feet or less.

Chemical analyses of eight lignite samples from Crowleys Ridge are on record with the U.S. Geological Survey's National Coal Resources Data System. Two of the samples are from the Wilcox Group, and six are from the Claiborne Group, but the lignite beds from which the samples were taken are unidentified. However, the analyses are believed to be representative of the lignite within the lignite-bearing sequence. The two Wilcox samples had moisture values of 36.3 and 40.1 percent; ash, 30.5 and 20.5 percent (U.S. Bureau of Mines); sulfur content, 0.3 and 1.0 percent; and Btu values, 3,910 and 4,590 on an as received basis. The six Claiborne samples had moisture values ranging from 34.7 to 43.7 percent; ash from 11.9-28.2 percent (USBM); sulfur content, 0.3-3 percent; and Btu values, 3,400 to 5,160. U.S. Geological Survey average ash content for the eight samples was 36.22 percent, and the major oxides are  $\text{SiO}_2$  (60.75 percent),  $\text{Al}_2\text{O}_3$  (15.23 percent),  $\text{CaO}$  (6.96 percent),  $\text{Fe}_2\text{O}_3$  (6.65 percent), and  $\text{SO}_3$  (5.64 percent). No anomalous values were recorded for the trace element content.

Lignite is not currently mined on Crowleys Ridge. It has potential for use as a fuel for direct firing of boilers to generate electricity. It also has potential for gasification to produce pipeline gas, and for liquefaction to produce fuel oil. More drilling and analyses are needed

to better define the quantity and quality of lignite beds within the four significant areas with resource potential and to determine the extent of lignite beds 2.5 ft or more thick that occur in several isolated areas.

## Introduction

### Purpose of Report

This report is a synthesis and correlation of basic drill-hole data from the Arkansas Geological Commission's lignite exploration project on Crowleys Ridge in northeastern Arkansas, during 1975 and 1976, and private company drill-hole data acquired by Arkansas. These data are used to interpret the stratigraphic framework of lignite beds and associated strata. A map was constructed to show areas underlain by at least one lignite bed 2.5 feet or more thick that has resource potential.

The drilling program was designed for near-surface lignite and the holes were limited to a 300 foot depth. The Commission drilled 116 holes on Crowleys Ridge and the location, elevation, and lithologic description of the rock cuttings and core of each of the drill holes has been published in Clardy, 1979 and Holbrook, 1980. Drill-hole-location maps in these reports also show the locations of 133 drill holes from lignite investigations of private companies whose records are on file with the Commission and were released to the U.S. Geological Survey.

Regional geologic characteristics of Crowleys Ridge were described and interpreted from earlier works by Call (1891), Hosman and others (1968), Murray (1961), Spooner (1935), Stephenson and Crider (1916), and Renfroe (1949), and from the records of several deep oil and gas test wells.

### Location and Size of Area

Crowleys Ridge is located in northeastern Arkansas within lat.  $34^{\circ} 30'$  to  $36^{\circ} 30'N$  and long.  $90^{\circ} 10'$  to  $90^{\circ} 49' W$  (index map, plate 1). It is an elongate, irregular and slightly arcuate ridge that extends from the north border of Arkansas southward about 145 miles to where it intersects the



Mississippi River. The ridge ranges from about 1 to more than 12 miles in width.

The area discussed in this report is limited to the part of Crowleys Ridge that extends from the north border of Arkansas southward to the south border of Cross County, Arkansas, at about lat.  $35^{\circ} 9' N$ . This part of the ridge has a length of approximately 100 miles and is within townships 6-21 north and ranges 2-8 east (plate 1). This area includes the published lignite investigations for Crowleys Ridge (Clardy, 1979; Holbrook, 1980).

#### Acknowledgments

The Arkansas Geological Commission, Little Rock, Arkansas, is gratefully acknowledged for supplying the basic data regarding lignite exploration on Crowleys Ridge. I am thankful to Ms. Bettie Hackman for completing the numerous computer stratigraphic forms of lignite drill-hole data for entry into the National Coal Resources Data System. Her work enabled the retrieval of computerized lithologic strip logs, used for stratigraphic correlation, that otherwise would have required laborious hand plotting. This entry and retrieval of data would not have been possible without help from members of the National Coal Resources Data System.

### Geologic Setting

Crowleys Ridge is an erosional remnant in the Gulf Coastal Plains of northeastern Arkansas that stands from 100 to 250 feet above the alluvial plains to the east and west, and is separated from these plains by escarpments of varying degrees of steepness. The origin of the ridge is thought to be the result of erosion by the Mississippi River and its tributaries which occupy large drainage areas to the east and west of the ridge and have cut down the alluvial plains, thus far sparing Crowleys Ridge, (Call, 1889; Spooner, 1935; Stephenson and Crider, 1916). Modern drainage is continually eroding the ridge, especially tributaries of the Mississippi River which lie very close to its east flank. The ridge is capped in many places by alluvium and loess of Quaternary age, and sand and gravel beds of the Lafayette Formation of Pliocene (?) age which creep down the slopes and mantle much of the underlying bedrock; however, exposures on the boundary escarpments and drainage valleys can be used to map the geology of the ridge. The boundary escarpments and draining valleys are shown on the geologic map of Arkansas (Haley and others, 1976) and on the preliminary geologic map of the Gulf Coastal Plain of Northeastern Arkansas (Stephenson and Crider, 1916).

Crowleys Ridge is in the northwestern part of the Mississippi embayment, which is a geosynclinal feature whose axis trends approximately in the direction of the modern Mississippi River. The embayment geosyncline plunges southward and opens into the Gulf of Mexico. Structural dip of the bedrock in the vicinity of Crowleys Ridge ranges from 35 to 75 feet per mile in a southeast to east by southeast direction towards the axis of the geosyncline.

Numerous publications are available that describe the Gulf coastal plains and the Mississippi embayment but no attempt is made to summarize

this information. Two references are especially useful in reviewing the geologic setting of Crowleys Ridge: One is the "Geology of the Atlantic and Gulf Coastal Province of North America" by Grover E. Murray (1961); and the other is "Tertiary Aquifers in the Mississippi Embayment" by Hosman and others (1968). The latter report contains a good set of stratigraphic cross sections derived from electric logs, which cover much of the embayment.

### Stratigraphy

A geologic cross section, which includes the lignite-bearing rocks of the Tertiary (Paleocene-Eocene) Midway, Wilcox, Claiborne, and Jackson Groups (pl. 2), was constructed along and adjacent to Crowleys Ridge from oil and gas drill holes to determine the regional structure and stratigraphy. The drill holes data are contained in Renfroe (1949). These holes are, from north to south:

U-Tex Oil Company drill hole no. 1, located in the SW SW SW of section 26, T. 20 N., R. 7 E. Clay County, Arkansas (pls. 1 & 2).

Volcanic Oil and Gas Co. drill hole no. 1 located in sec. 16, T. 16 N., R. 5E, Green County, Arkansas (pls. 1 & 2).

J.F. Scott, Trustee well no. 2-A located in sec. 12, T. 11 N., R. 3 E. Poinsett County, Arkansas, (pls. 1 & 2)

Ronnie Smith and Cockburn Oil Co. drill hole no. 1, located 285 ft from northline, 420 feet from eastline of the NW NW, sec. 14, T. 2 N., R. 1 E., Lee County, Arkansas (this hole is off the limits of pls. 1 & 2).

These drill holes span a distance of about 115 miles and have been drilled into Cretaceous formations but only part of the section down to the base of the Tertiary rocks was plotted. The U-Tex drill hole in Clay County penetrated about 45 feet of Plio - Pleistocene gravels which lie unconformably on Paleocene-Eocene sediments of the Wilcox Group. The oldest post-Eocene sediments are possibly Pliocene in age (Spooner, 1935; Hosman and others,

1968). The Wilcox Group is about 560 feet thick, but is not a complete stratigraphic section because of erosion prior to the deposition of the overlying gravels. The Midway Group, underlying the Wilcox, is about 270 feet thick and includes 10 feet of the Clayton Formation at the base of the Midway - rocks. Thus, the total Wilcox and Midway section in the U-Tex drill hole, near the northern end of Crowleys Ridge, is about 830 feet thick.

The Volcanic drill hole in the southern part of Green County is about 27 miles southwest from the U-Tex hole. The line of section is just off the structural northeast-southwest strike so that the apparent dip of the formations is southward about 3 to 6 feet per mile. The Volcanic hole contains about 210 feet of post-Eocene sediments which lie unconformably on the Wilcox Group. Note: there can be large variations in the thickness of post-Eocene sediments from place to place because of variations in the modern surface erosion. The surface profile is not shown on the regional cross section. The Wilcox Group in the Volcanic hole is about 480 ft thick, which is thinner than at the U-Tex drill hole, probably because of differential erosion at the unconformity after uplift at the close of Eocene times. The Midway Group, underlying the Wilcox is 355 ft thick. The Clayton Formation at the base of the Midway is not recognized in this hole. The Midway is thicker in the Volcanic test than it is in the U-Tex hole and demonstrates the gradual thickening of the formation from north to south. The combined thickness of the Wilcox and Midway is 835 feet.

The J.F. Scott drill hole in Poinsett County is about 30 miles south-southwest of the Volcanic hole. The line of section between the two holes is diagonally across strike and the dip is 17 to 20 feet per mile southward. The J.F. Scott hole possibly contains as much as 210 feet of post-Eocene

sediments, but lithologic descriptions to confirm this are not available. These sediments unconformably overlie an estimated 180 feet of the Claiborne Group. As shown on the regional cross section the contact between the Wilcox and overlying Claiborne is between the Volcanic and J.F. Scott drill holes. The Claiborne Group has been truncated by uplift and erosion after the close of Eocene times, and only the basal part of the Claiborne is represented in the S.F. Scott hole. The underlying Wilcox Group is about 780 feet thick. The Midway Group underlying the Wilcox is 440 feet thick, which is thicker than it is in the Volcanic hole, and again illustrates thickening to the south. Total thickness of the Claiborne, Wilcox, and Midway groups in the S.F. Scott hole is about 1,420 feet.

The Ronnie Smith drill hole in Lee County is located west of Crowleys Ridge, but probably represents closely the stratigraphic intervals in the ridge. This location is about 58 miles south-southwest of the J.F. Scott hole, and the strata dip 17 to 20 feet per mile southward between the two holes. The Ronnie Smith hole contains an estimated 250 feet of younger, post-Eocene sediments. These sediments unconformably overlie 490 feet of the Jackson Group, whose basal contact with the Claiborne is in the southern part of Cross County. The truncated up-dip edge of the Claiborne extends for about 28 miles from the J.F. Scott drill hole towards the Ronnie Smith hole before these sediments dip under the Jackson Group (pl. 2). The total stratigraphic thickness of the Claiborne Group is 690 ft in this area. The Wilcox underlying the Claiborne is 775 feet, or about the same as in the J.F. Scott drill hole. The Midway Group under the Wilcox is 525 feet thick and includes 80 feet of the Clayton Formation at the base of Midway. Total Paleocene-Eocene sediments in the Ronnie Smith is 2,480 feet.

It can be seen by the regional geologic cross section (pl. 2) that the lignite-bearing formations of Paleocene-Eocene age thicken from about 830 feet in the U-Tex drill hole near the north end of the ridge to about 2,480 feet in the Ronnie Smith drill hole toward the south end of the ridge. This thickening of section is mostly due to the addition of younger sediments that have been deposited down-dip and have not been eroded away upon later up-lift at the end of the Eocene time. Under the post-Eocene to recent deposits that mantle the surface of Crowleys Ridge the unconformable bedrock surface becomes generally younger in age from north to south along the ridge. The partially eroded Wilcox Group is at the bedrock surface in Clay, Green, and part of Craighead County, the base of the Claiborne Group is the bedrock surface in southern Craighead County and becomes progressively younger southward through Poinsett County, to near the south border of Cross County where the top of the formation is in contact with the base of the Jackson Group. The area of this report (pl. 1) that involves the near surface lignite exploration drilling has its bedrock surface almost entirely in the Wilcox or Claiborne sediments.

#### Lithology and Depositional Environment of the Wilcox and Claiborne Groups

##### Wilcox Group

The Paleocene - Lower Eocene Wilcox of northeastern Arkansas, in and around Crowleys Ridge, is composed of continental to deltaic deposits consisting of interbedded clays, silts, and sands that are commonly lignitic or carbonaceous, and beds of lignite (Murray, 1955, 1961). Spooner (1935) describes the Wilcox as a series of sands, clays and sandy clays, with beds of carbonaceous clay and lignite. Marked lateral variations are common. Stephenson and Crider (1916) describe the Wilcox as irregularly

bedded sands, locally indurated to sandstones and quartzites, and irregularly bedded varicolored clays with interbedded layers of lignite. Caplan (1954) describe the Wilcox as consisting of brown shale, gray micaceous shale, gray and gray-green siltstones and clays, and thick sand beds.

Lignite and siderite layers occur frequently in the Wilcox.

Studies of the Wilcox in east Texas (Kaiser, and others, 1980) and northern Mississippi (Cleaves, 1980) have shown that the Wilcox was deposited in a fluvial environment with some deltaic influence. The lignite beds were formed in swamps between stream channels of the dendritic fluvial environment or in smaller interdistributary basins in the delta plain. The sedimentary models of east Texas and northern Mississippi could well apply to the Crowleys Ridge area, and to the distribution of lignite in the Wilcox Group as described later in this report.

#### Claiborne Group

The lithologic break between the Wilcox and Claiborne Groups is placed at the contact between the clay, silt, and sand sequence at the top of the Wilcox, and the predominantly sand sequence at the base of the Claiborne. This lithologic change has been noted in the Ronnie Smith drill hole and is plotted on plate 2, and shown on the Geologic Map of Arkansas. However, the Wilcox-Claiborne contact could not be clearly identified from the near-surface lignite exploration drilling so the contact was determined on the basis of sub-surface projection and the Arkansas geologic map. The contact between the Wilcox and Claiborne is also the contact between the Lower and Middle Eocene as determined by palynomorphs identified by Frederiksen and others (1982) from the New Madrid test well of southeast Missouri, about 30 miles to the east of Crowleys Ridge. The New Madrid test well samples are

considered by Frederiksen and others (1982), as the "laboratory" for the lithology of the northern Mississippi embayment, especially where the Tertiary sediments are generally non-marine to near-shore in origin. The Claiborne Group consists of white to light gray quartzose sands, and light to dark colored micaceous sands, interbedded with clays and sandy clays containing thin beds of lignite. The sands are fine to very coarse grained and the clays are massive to thinly laminated with fine, micaceous sand partings. In places clays contain iron carbonate concretions.

#### Near Surface Lignite Exploration Drilling

Drilling for lignite on Crowleys Ridge was mostly done along roadways and the holes were spaced from less than a mile to more than two miles apart depending on availability of unobstructed sites. The depth of the drill holes did not exceed 300 feet, which means that the holes just "skimmed" the surface of the Wilcox and Claiborne formations after penetrating post-Eocene alluvium, loess, and gravels. The irregularly eroded post-Eocene deposits varied considerably in thickness from zero to more than 200 feet and because of a 300 feet drilling limitation for strippable resources, the underlying Wilcox and Claiborne penetrated varied accordingly. Variations in thickness of the rock units also are due to the irregularly eroded Paleocene-Eocene bedrock surface upon which post-Eocene sediments were deposited.

To illustrate the vertical and horizontal characteristics of the lignite beds a series of seven cross sections (designated A-A' to G-G'; pls. 3 thru 9) were constructed from drill hole data. The cross sections were drawn from north to south with cross section A-A' the most northerly, and G-G' at the south end of that part of the ridge where near surface drilling was done (pl. 1). A description of each of these cross sections, including significant lignite-bearing areas, are reported as follows:



Cross section A-A' and area 1 (pls. 1 and 3).

This cross-section was interpreted from seven geophysical logs which contain density and resistivity curves. The line of section trends south-westward in the middle of Clay County for a distance of about 9 miles. The alluvium and loess, and Lafayette formation sand gravel beds range in thickness from 30 to 100 ft, and the thickness of Wilcox penetrated ranges from approximately 130 to 200 ft in the holes along this line of section. Two lignite beds were penetrated in these holes, designated beds 1 and 2 in zone 1. Bed 1, the uppermost, is from 1.5 to 4 ft thick excluding a parting, at a depth of from 100 to 170 feet. The bed is discontinuous along section, where it apparently is absent in hole 214 (Arkansas Geological Commission number; Holbrook 1980) so that it extends without break for possibly two miles in two different segments. Bed 2, twenty feet or less below Bed 1, is from 1 to 5 ft thick (excluding a clay split) and apparently is continuous along the line of section for a distance of almost six miles. Bed 2 has a resource thickness of 2.5 ft or more in holes 214, 230, and 231 at the south end of the cross section. (Drill holes with a bed, or beds of lignite that are each 2.5 ft or more thick are shown as open circles on map (pl. 1); the holes in which lignite beds are less than 2.5 feet thick, or absent, are shown by solid dots.)

Area 1 with lignite bed 1 and 2, zone 1 has been estimated from the locations of holes 214, 230, and 231 of cross section A-A': The beds within this area range in thickness from 2.5 to 5 ft with a excluding, as indicated in cross section A-A', and cover an area of about two square miles. Area 1 is stratigraphically the lowest of four areas designated and lies near the middle of the Wilcox Group.

Cross section B-B' and area 2 (pls. 1 and 4).

This cross section was interpreted from 13 geophysical logs similar to those in cross section A-A'. The line of section trends roughly southward with a sharp jog to the east, and is within the northern to central part of Green County. The section is about 15 mi long. Surficial post-Eocene alluvium and loess and gravels range from a few feet to nearly 200 feet thick, and the thickness of Wilcox Group penetrated is from about 60 to 290 feet along the line of cross section. Three lignite beds were penetrated in these holes, designated beds 1, 2, and 3 in zone 2. Bed 1, the uppermost of zone 2, ranges from 1.5 ft to 6 ft in thickness, and occurs at a depth from about 40 feet to 280 feet. The bed is probably continuous along the line of section, and is faulted between holes 256 and 243, and 224 and 200, respectively. Offset of bed 1 by the fault between holes 256 and 243 is about 90 feet, and between holes 224 and 200 is about 60 ft. Bed 2, which lies from a few feet to 20 feet below bed 1, ranges from 0 to 4 ft in thickness. Bed 2 appears continuous, although faulted, between holes 247 and 200, a distance of about 3 miles but locally is absent due to faulting. The bed is a few inches thick in hole 197 about 4 miles south of hole 200. Bed 3 of zone 2 lies from a few feet to 15 ft below bed 2 and ranges in thickness from 2 to 3 ft. It is continuous along the same holes as with bed 2.

Area 2 designates two separate areas in Green County that contain one or more lignite beds that are more than 2.5 ft thick but are separated by lignite less than 1.5 feet thick in hole 245. The size of both parts of area 2 north and south is determined by the location of drill holes that contain one or more lignite beds at least 2.5 ft thick as well as other holes in the vicinity of the line of cross section, believed to contain the

same beds of zone 2. Area 2 also includes two holes that are part of the north end of cross section C-C' to be described below. The north part of area 2 contains one lignite bed from 3 to more than 4 ft thick and occupies about 6 sq mi. The south part of area 2 includes at least one hole (247) with 3 lignite beds, each 2.5 ft or more thick, whereas the remainder of the area contains at least 1 or 2 beds, each 2.5 or more thick (see cross section B-B'). The estimated size of the south part of area 2, a very irregular area, is at least 12 square miles. The lignite beds of zone 2, are believed to be stratigraphically higher than those in zone 1 of area 1, and are stratigraphically in the upper third of the Wilcox Group. With the shallow lignite exploration drilling it has not been entirely possible to relate lignite beds to specific stratigraphic horizons within the Wilcox-Claiborne Groups.

#### Cross section C-C' (pls. 1 and 5)

This cross section has been interpreted from logs of 12 drill test holes. Five of the logs are geophysical and seven are lithologic logs. From near the center of Green County the line of section trends about 15 mi to the south. Surficial post-Eocene deposits are from 10 to 160 feet thick and the Wilcox drilled ranges from 0 to 300 ft. The northern two holes, of the cross section, encountered a lignite that is correlated to bed 3 of zone 2 as seen in cross section B-B'. Bed 3 penetrated by these two holes is a part of area 2 and is 4 to 4.5 ft thick. Bed 3 also was found in holes 12 and 15 near the middle part of the cross section but is only 1 to 2 ft thick and again at the southernmost hole, where it is 3 ft thick. The correlation of bed 3, zone 2, along the 15 mi of cross section C-C' shows a southerly dip of about 10 ft per mile which is reasonable in view of regional dips estimated for this part of Crowleys Ridge (pl. 2).

Cross section D-D' and area 3 (pls. 1 and 6)

This cross section was constructed from geophysical and lithologic logs of 11 drill hole logs. The line of section trends nearly south for about 14 miles from the south end of Green County, just south of the Craighead County line, towards the southern part of Craighead County. Surficial sediments are from 0 to 160 ft thick, and the Wilcox Group penetrated ranges from about 20 to 230 ft thick because of drilling limitations. The northernmost hole of cross section D-D' is common with the southernmost hole of C-C', which means the two sections are continuous with each other. Bed 3, zone 2, has been correlated in cross section D-D', but it is discontinuous, similar to section C-C'. Bed 3, in section D-D' is from 2 to 5 ft thick. Bed 2 of zone 2, first seen in cross section B-B', also occurs in this section in one hole (169) and lies about 15 feet above bed 3; however, it is only 1 ft thick. Cross section D-D' contains three additional lignite beds stratigraphically higher than zone 2. These beds are included in zones that are designated, from older to younger, zones 3, 4, and 5. The designation zone for these single beds is used to allow for any close-set beds which may be discovered in subsequent drilling to be added to each zone. Zone 3 lies about 50 ft above bed 3, zone 2, and are separated by a sandstone unit in several of the drill holes. Zone 3 lignite is first seen in hole 258 and then again in two holes about six miles south, near the south end of the section, within area 3. Zone 4 lignite bed is 60 to 80 ft above zone 3 and is from 2 to 6 ft thick. It also is within area 3. Zone 5 lignite was identified in a single hole about 80 ft above zone 4 and is 4 ft thick. Zone 5 lignite is within area 3. Therefore area 3, as seen in cross section D-D', contains 4 lignite zones, and each hole contains one or two beds 2.5 ft or more thick. The depth to the

lignite ranges from about 70 to 270 ft. The size and shape of area 3 was estimated from holes in cross section D-D' as well as other holes in the same area which contain one or more lignite beds in zones 2 to 5. Lignite in these other holes is as much as 9.5 ft thick, and the size of the area is estimated to be 7 to 8 sq mi. The stratigraphic position of lignite beds in area 3 is in the upper part of the Wilcox Group.

Cross section E-E' (pls. 1 and 7)

This cross section has been interpreted from geophysical and lithologic logs of 9 drill holes. The northermost hole is common to the southernmost hole of section D-D'. The line of cross section trends east by southeastward, following a major curve in the shape of Crowleys Ridge, and is about 12 mi long, ending near the south border of Craighead County. The thickness of deposits above the unconformity with the underlying bedrock ranges from 10 ft to about 280 ft. Cross section E-E' crosses the contact between the Wilcox and Claiborne Groups as shown in pl. 2 and on the Geologic Map of Arkansas. The cross section contains bed 3, zone 2, as described for the section above, and which is part of area 3, and hole 72 adjacent to the south encountered zone 4 lignite which is only 1 ft thick. The southernmost hole (62) of cross section E-E' contains a lignite bed believed to be stratigraphically higher than zone 3 and is designated zone 6. This bed is split with the upper bench 5 ft thick, and the lower bench 1-foot thick.

Upon reviewing cross sections A-A' to E-E' it can be seen that lignite beds in zones 1 to 5, are located stratigraphically from about the middle to the top of the Wilcox Group, and subsequent zones are in the overlying Claiborne Group.

Cross section F-F' and area 4 (pls. 1 and 8).

Cross section F-F' has been interpreted from geophysical and lithologic logs of 9 drill holes. The northernmost hole of the section is common to the southernmost hole of cross section E-E'. The line of cross section trends southward for about 12 mi, starting at the south end of Craighead County, just north of the border with Poinsett County, and ending in the middle of Poinsett County. The surficial deposits are relatively thin along this cross section, ranging from 0 to 60 ft thick. The thickness of Claiborne drilled ranges from about 100 to 300 ft. The 5 ft lignite bed of zone 6 (hole 62) at the north end of the cross section has been removed by erosion to the south, but has been identified in the south-most 4 holes. These last 4 holes penetrated lignite assigned to zone 6 that ranges from 2 (excluding split) to 4+ ft in thickness and is up to 7 ft thick in other holes. The last three holes are in the north and largest part of area 4 which consists of three parts that contain the same discontinuous lignite bed. Hole 123 at the south end of cross section F-F' contains a stratigraphically higher lignite bed that is designated as zone 7 and is the youngest lignite bed described in this report. The lignite of zone 7 is about 300 ft above the base of the Claiborne Group which is approximately in the middle of the Group. The lignite in hole 123 is thought to have been down-faulted to the south about 50 ft with respect to hole 122 causing a steepening of the dip between the two holes.

The north part of area 4 contains at least one lignite bed 2.5 ft or more thick and defines an area of about 4 square miles in size as determined from data from 12 test holes.

Cross section G-G' and area 4 (pls. 1 and 9).

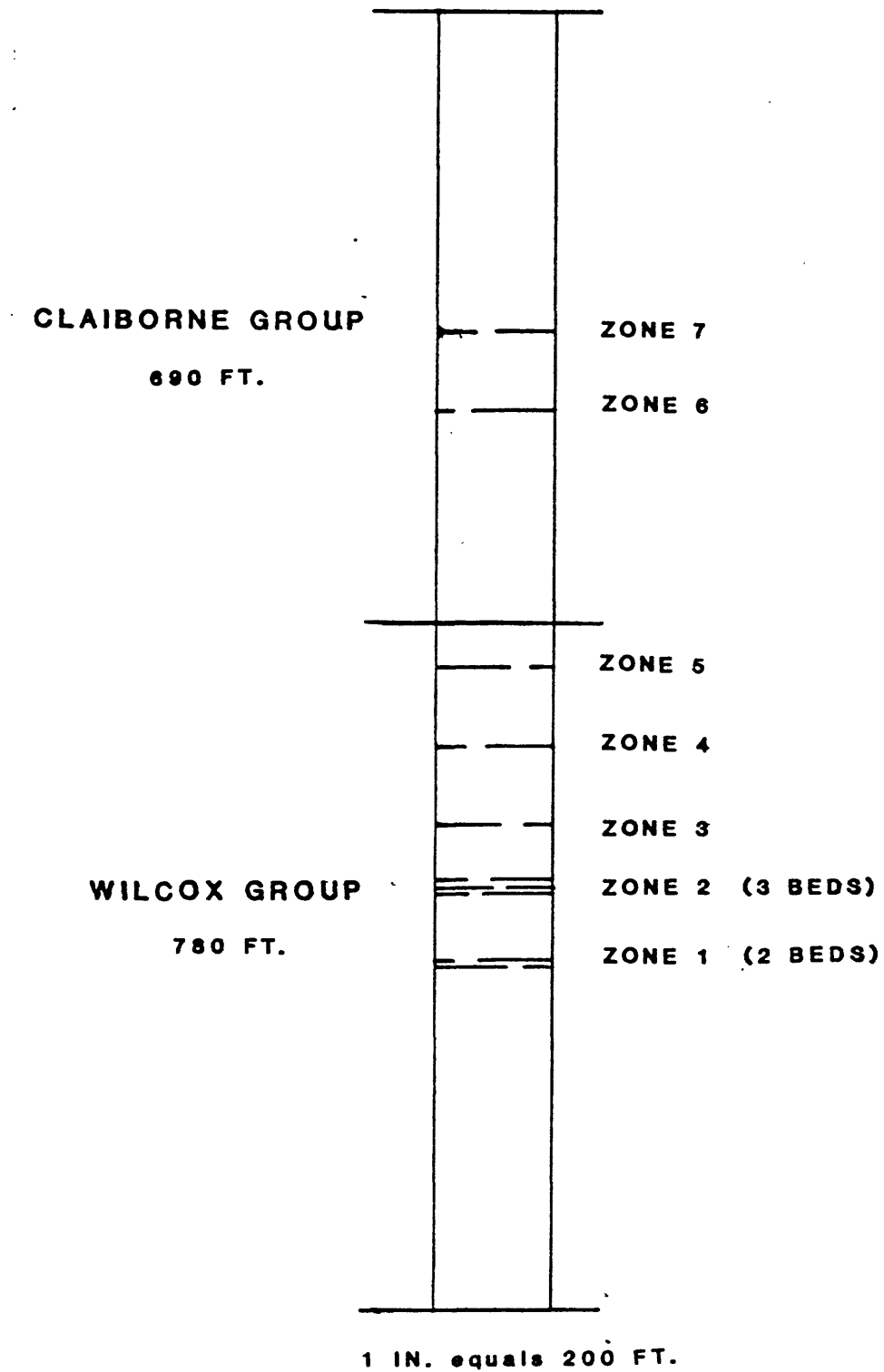
This cross section has been interpreted from geophysical and lithologic logs of 8 drill holes. The northernmost hole of the section is the same as the southernmost hole in cross section F-F', which has made a continuous line of cross sections starting with C-C'. Cross section G-G' trends southward for about 13 miles, starting in the middle of Poinsett County on Crowleys Ridge and ending in the north part of Cross County. The surficial deposits above the unconformity are absent or are as much as 90 ft thick. The Claiborne penetrated by the holes along the cross section, ranges from 0 to 300 ft thick and includes zone 6, and zone 7 lignite beds. Zone 6 lignite is from 1 to 4 ft thick, and zone 7 from 2 to 3.5 ft thick. The northern part of cross section G-G' is in the north part of area 4, and holes 166 and 156 are included in the southern two parts of area 4. The southern parts are separated from the northern part by the absence or thinning of lignite. These areas are estimated to cover about a square mile.

Summary of Significant Lignite Deposits on Crowleys Ridge

Areas containing one or more lignite beds at least 2.5 ft or more thick have been delineated from the interpretation of data from near-surface lignite exploration drill holes. Cross sections constructed from drill-hole logs have helped determine the number, extent, and stratigraphic sequence of lignite beds discovered on Crowleys Ridge.

Ten lignite beds whose thickness locally exceeds 2.5 ft have been identified in this study. These beds have been divided into seven zones, with zone 1 being the stratigraphically lowest and oldest, and zone 7 being the highest and youngest (fig. 1). Zone 1 occurs about in the middle of the

FIGURE 1  
COMPOSITE STRATIGRAPHIC COLUMN SHOWING APPROXIMATE  
POSITION OF LIGNITE ZONES AND BEDS  
CROWLEYS RIDGE , ARKANSAS





Wilcox Group at the north end of Crowleys Ridge. The formations dip gently southward and subsequent zones are progressively higher stratigraphically from north to south along Crowleys Ridge until zone 7 near the middle of the Claiborne Group is reached near the southern part of the ridge. The stratigraphic interval from zone 1 to zone 7 is estimated to be about 700 feet and extends horizontally about 70 miles. All drilling was limited to depths of 300 feet or less. Zone 1 contains two lignite beds, zone 2 contains three beds, and zones 3 through 7 contain one bed each. The zone designation is used in the case of single beds because later drilling may reveal more than one related lignite bed, thus making the zone classification valid. Four areas have been outlined that contain significant lignite beds at least one of which is 2.5 ft or more thick, and all beds are less than 300 ft deep. The description of these areas is shown<sup>in</sup> table 1.

Table 1

AREAS CONTAINING SIGNIFICANT LIGNITE ON CROWLEYS RIDGE, ARKANSAS							
Area No.	Location	Size of Area in Sq. Miles	Number of lignite beds and thickness	Depth range to lignite beds	Stratigraphic Group	Stratigraphic zone of the lignite beds	Remarks
1	T. 20N R. 7E (western part) Clay County	4	2 beds 2.5 to 5 ft.	100-190	Wilcox	1	
2	T. 17N-19N. R. 4-5E Green County	north part 6 south part 12	north part 1 bed 3-4 ft south part 3 beds 2.5-6 ft	40-240	Wilcox	2	Area 2 is in two parts; a north and south part. The area apparently contains two faults.
3	T. 14N. R. 2-3 E Craighead County	7-8	4 beds 2.5-9.5 ft.	80-290	Wilcox	2 to 5	
4	T. 10-11 N. R. 4E. Poinsett County	north 4 middle and south 1 each	north part 2 beds 2.5 - 7ft south part 1 bed 2.5 - 3.5	20-160	Claiborne	6 and 7	Area 4 is in 3 parts, north middle, and south. The north part apparently contains a fault.

NOTE: This table could be in reverse order with younger Claiborne on top of Wilcox - but this would not fit the order of description in the text - which is from older zone 1 to younger zone 7 (bottom to top).

### Chemical Composition of Crowleys Ridge Lignite

The analyses of eight lignite drill core samples from Crowleys Ridge are on record in the U.S. Geological Surveys National Coal Resources Data System. Two samples are from the Wilcox Group and six are from the Claiborne Group. It is not know which lignite beds these samples come from but they probably are representative of the lignite in the general area. The two Wilcox samples (from same drill hole) appear to have come from near area 3 as defined in this report, and the six Claiborne samples are from in or near area 4 (fig. 2). Summaries of the proximate and ultimate, and major and minor oxide analyses of the eight samples are shown in tables 2 and 3.

The lignite on a "whole-coal" basis, was analized for 61 trace elements, 29 of which had suffcient values to average. None of the average values were anonomously high. Potentially toxic elements in the lignite samples, although not high in content, are listed in table 4 with the average content in parts per million, and the number of samples averaged.

### Utilization of Crowleys Ridge Lignite and Recommendations for Further Work

Lignite is not mined on Crowleys Ridge at present, nor are there any known plans to mine the lignite but it has resource value and could be used for direct burning in boilers to generate electricity. It's properties for conversion to synthetic fuels are unknown, but lignites in general have potential for gasification to produce pipe line gas, and for liquifaction to produce fuel oil.

It is recommended that more drilling be planned to better define the quantity and quality of lignite beds within significant areas 1, 2, 3, and

FIGURE 2

## INDEX MAP

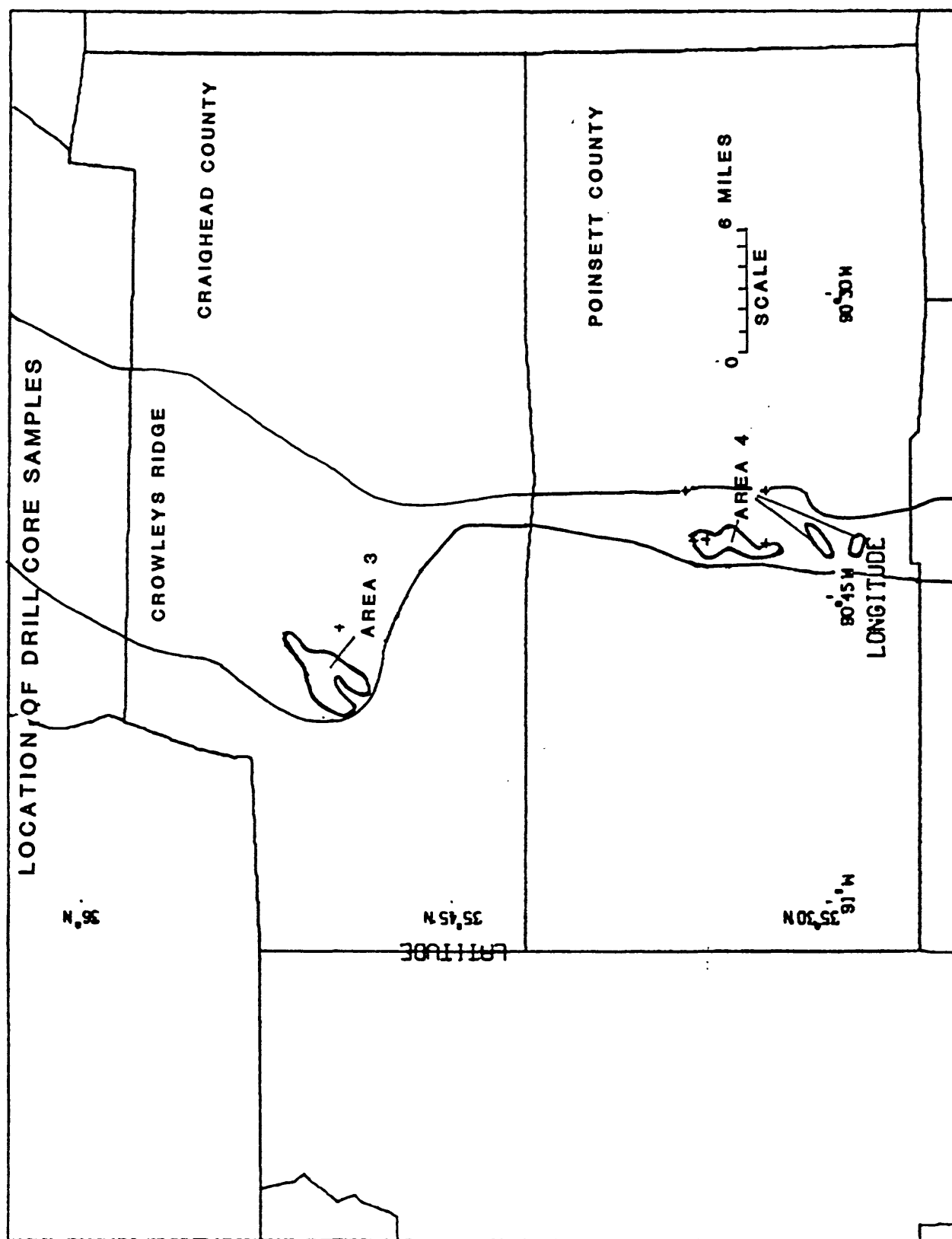


TABLE 2

Summary of part of the proximate and ultimate analyses of lignite samples  
(range and average as received)

Formation	Moisture %	Ash % (USBM @750°)	Sulfur %	Btu/lb
Wilcox Group (2 samples)	36.3 - 40.1	20.5 - 30.4	0.3 - 1.0	3910 - 4590 6138 - 7663 (moisture free)
Claiborne Group (6 samples)	34.7 - 44.2	11.9 - 28.2	0.3 - 3.0	3400 - 5160 5822 - 9448 (moisture free)
Averages	39.90	22.54	0.79	4368 7305 (moisture free)

TABLE 3

Averages of major and minor oxide composition of the 8 lignite samples  
(laboratory ash)

Ash % (USGS @ 525° C)	SiO <sub>2</sub> %	Al <sub>2</sub> O <sub>3</sub> %	CaO %	Fe <sub>2</sub> O <sub>3</sub> %	SO <sub>3</sub> %	MgO, Na <sub>2</sub> O, K <sub>2</sub> O TiO <sub>2</sub> and P <sub>2</sub> O <sub>5</sub> %
36.33	60.75	15.23	6.96	6.65	5.64	4.77

TABLE 4

Potentially toxic elements and number of samples averaged  
(whole coal - parts per million)

Ag	Al	Be	Cd	Cr	Cu	Hg	Ni	Pb	Sb	Se	Ni
43(1)	2.99(8)	2.96(6)	5.33(2)	33.76(8)	31.52(8)	0.30(8)	9.70(8)	14.39(8)	0.89(7)	3.27(6)	9.70(8)

4, and to determine the extent of lignite 2.5 feet or more thick found in several single, isolated, drill holes on Crowleys Ridge as shown in plate 1.

## References cited

- Call, R.E., 1891, The geology of Crowleys Ridge, Arkansas: Arkansas Geological Survey Annual Report, v. 2, 283 p.
- Caplan, W.M., 1954, Subsurface geology and related oil and gas possibilities of northeastern Arkansas: Arkansas Division of Geology, Bulletin 20, p. 94-95.
- Clardy, B.F., 1979, Arkansas lignite investigations: Arkansas Geological Commission, preliminary report, 133 p.
- Cleaves, A.W., 1980, Depositional systems and lignite prospecting models: Wilcox Group and Mendiarc Sand of northern Mississippi: Transactions - Gulf Coast Association of Geological Societies, v. 30, p. 283-307.
- Frederiksen, N.O., Bybell, L.J., Christopher, R.A., Crone, A.J., Edwards, L.E., Gibson, T.G., Hazel, J.E., Repetski, J.E., Russ, D.P., Smith, C.C., and Ward, L.W., 1982, Biostratigraphy and paleoecology of Lower Paleozoic, Upper Cretaceous, and Lower Tertiary rocks in U.S. Geological Survey New Madrid test wells, southeast Missouri: Tulane studies in Geology and Paleontology, v. 17, No. 2, p. 23-45.
- Haley, B.R., Glick, E.E., Bush, W.V., Clardy, B.F., Stone, C.G., Woodward, M.B., and Zachry, D.L., 1976, Geologic Map of Arkansas, Arkansas Geological Commission, and U.S. Geological Survey.
- Holbrook, D.F., 1980, Arkansas lignite investigations: Arkansas Geological Commission, preliminary report, 157 p.



- Hosman, R.L., Long, A.T., and Lambert, T.W., 1968, Tertiary aquifers in the Mississippi embayment; U.S. Geological Survey Professional Paper 448-D, 28 p.
- Kaiser, W.R., Ayers, W.B., Jr., and La Brie, L.W., 1980, Lignite resources in Texas: Bureau of Economic Geology, The University of Texas at Austin, and Texas Energy and National Resources Advisory Council, Report of Investigations No. 104, 52 p.
- Murray, G.E., 1955, Midway Stage, Sabine Stage, and Wilcox Group: Bulletin of the American Association of Petroleum Geologists, Vol. 39, No. 5, pp. 671-696.
- Murray, G.E., 1961, Geology of the Atlantic and Gulf coastal province of North America: Harpers geoscience series, Harpers & Brothers, Publishers, New York, 692 p.
- Renfro, C.A., 1949, Petroleum exploration in eastern Arkansas with selected well logs: Arkansas Resources and Development Commission, Division of Geology, Bulletin 14, 159 p.
- Spooner, W.C., 1935, Oil and gas geology of the Gulf Coastal plain in Arkansas: Arkansas Geological Survey Bulletin 2, 516 p.
- Stephenson, L.W., and Crider, A.F., 1916, Geology and ground waters of north-eastern Arkansas: U.S. Geological Survey Water-Supply Paper 399, 313 p.
- U.S. Geological Survey, 1983, National Coal Resources Data System, Reston, VA